

## WOOD RIVER COHO SALMON ENUMERATION, 1994



by

Thomas E. Brookover

and

Linda K. Brannian

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## **PREFACE**

This manuscript is intended to satisfy department reporting requirements set forth in a Cooperative Agreement (95-012) between the Alaska Department of Fish and Game and Bering Sea Fishermen's Association. The purpose of the agreement was to operate the Wood River Coho Salmon Escapement Monitoring Project, a first-time attempt to measure coho salmon escapement into the Wood River system in Bristol Bay. Information obtained by the project was meant to be used in and improve the management of subsistence and commercial fisheries in the Nushagak District.

## **AUTHORS**

Thomas E. Brookover is the Region II West Side Bristol Bay Area Management Biologist for the Alaska Department of Fish and Game, Division of Commercial Fisheries Management and Development, P.O. Box 230, Dillingham, AK 99576-0230.

Linda Brannian is the Region II Area Regional Biometrician for the Alaska Department of Fish and Game, Division of Commercial Fisheries Management and Development, 333 Raspberry Rd, Anchorage, AK 995198.

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## ABSTRACT

Estimates of Pacific salmon *Oncorhynchus* escapement for the Wood River in Bristol Bay, Alaska, were estimated by counting tower procedures from August 1 through 24, 1994. The escapement was observed underwater through snorkeling to estimate species composition from August 9 through August 24. A total 45,162 Pacific salmon were estimated to pass the Wood River counting tower during August 1 through 24 of which 3,084 were estimated to be coho salmon for the period August 9 through 24.

KEY WORDS: Pacific salmon, counting tower, Wood River, Bristol Bay, escapement, estimation, fisheries management, *Oncorhynchus*

## INTRODUCTION

The Wood and Nushagak Rivers drain into Nushagak Bay, one of five major estuaries that comprise Bristol Bay (Figure 1). Widely known for sockeye salmon *Oncorhynchus nerka* production, the rivers of Bristol Bay support stocks of all five species of Pacific salmon *Oncorhynchus* sp. The rivers flowing into Nushagak Bay produce the largest runs of coho salmon *O. kisutch* in Bristol Bay; Nushagak coho runs have been estimated since 1980, and average approximately 197,000 fish (Beverly Cross, Commercial Fisheries Management and Development Division, Alaska Department of Fish and Game, Anchorage, personal communication). However, annual run estimates vary throughout the period from 39,971 in 1987 to 646,708 in 1982.

The coho runs to the Nushagak watershed are the focus of commercial, subsistence and sport harvests. Commercial coho landings have been documented in the Nushagak District (Figure 1) since 1893 (Middleton 1983). Recent (1980-1993) commercial harvests average approximately 100,000 coho salmon, worth \$455,000 to fishermen. Historically, coho salmon have provided a staple subsistence food for residents of the Nushagak watershed, harvested recently at an average (1984-1993) annual rate of 7,255 (Skrade et al. 1994). The majority of the Nushagak subsistence harvests of coho salmon occur in Nushagak Bay, but coho salmon are taken in subsistence harvests in the Nushagak and Wood Rivers as well. Sport harvest in the Nushagak and Wood Rivers has averaged (1989-1993) 1,593 coho salmon (Minard and Dunaway 1993).

Due to increasing commercial fishing pressure in the late 1970's, annual escapement assessment began in 1980, with a hydroacoustic sonar project located near Portage Creek on the Nushagak River (Brannian et. al *in press*). Nushagak River escapements through 1993 averaged 108,458 coho salmon, and are assumed to represent the primary stock component of the Nushagak Bay watershed. Currently, the entire catch of coho salmon in the Nushagak District is added to Nushagak River escapement for estimates of total return. Recently, poor production of Nushagak River coho stocks has resulted in poor returns, severely curtailed commercial fishing, and restricted subsistence and sport fishing. Run strength was so poor in 1993, that for the first time, subsistence fishing for coho salmon was closed.

Prior to 1994, Wood River coho escapement had never been assessed. Fishery impacts on this stock were unknown as was its relative importance compared to the Nushagak River stock. Information available for coho stocks in the Wood River system is limited to sport and subsistence harvest data. Sport harvests have been documented in the Wood River Lakes system since 1977 and have increased since 1985 to an average (1985-1993) of 570 coho salmon, roughly equivalent to harvests in the Nushagak River drainage. An average (1987-1994) 511 coho salmon were harvested for subsistence use in the Wood River system. Aside from anecdotal reports from local residents, sport and subsistence harvest data have provided the only indications of run strength in the Wood River. Although Nushagak Bay subsistence and commercial harvests include coho salmon bound for Wood River, Nushagak River, as well other systems, these fisheries are managed to achieve a spawning goal of 90,000 coho salmon in the Nushagak River. Exploitation on the Wood River stock is occurring at unknown rates, and is dependant on escapement trends in the Nushagak River.



The purpose of this project is to examine the feasibility of using counting towers and aerial surveys to estimate coho salmon abundance in the Wood River system. Counting towers have been used since the 1940's to estimate spawning abundance of sockeye salmon in Bristol Bay. However, no attempt has been made to specifically estimate coho salmon, prior to 1994. Aerial surveys have been used to assess coho salmon escapements in some areas of Bristol Bay. Due to protracted run timing evidenced by the commercial fishery and the Nushagak River sonar, low daily passage rates at the sonar, and a tendency for coho salmon to disperse throughout the large Nushagak watershed, aerial surveys have not been attempted to document coho salmon spawning escapement previously in the Nushagak watershed.

## METHODS

### *Counting Tower*

The Wood River coho counting tower project was conducted for a duration similar to that used for coho salmon estimation in the Nushagak River. The project began August 1, approximately one week after the Wood River sockeye salmon tower project terminated, and ended on August 25. Two counting towers were located on opposite banks of the river approximately 0.5 km below the outlet of Aleknagik Lake.

A crew of three people conducted systematic counts each hour for the duration of the project, using methods similar to those employed to count sockeye salmon from counting towers in Bristol Bay (Becker 1962, Seibel 1967). Visual counts were conducted every hour for 10 minutes on each river bank. Background panels were attached to the river bottom to facilitate fish identification, and high intensity floodlights were used to illuminate night migration. Observers used Polaroid sunglasses to reduce surface glare, and hand tally counters to accumulate counts.

Problems became apparent in separating sockeye and coho salmon in their non-spawning or bright coloration from the tower during the first week of the project. Beginning August 9, counts were recorded in one of four categories: (1) pink salmon *O. gorbuscha*, (2) sockeye salmon in obvious spawning configuration, (3) coho salmon in obvious spawning configuration, and (4) "bright" mixed fish, assumed to be sockeye or coho salmon.

Beginning August 7, technicians drifted downriver wearing mask and snorkels in the area of the tower and counted by species the salmon that could not be assigned as sockeye or coho salmon from the tower. These data were then used to apportion tower counts of "bright" mixed fish. Beginning August 9, drifts were conducted along both banks about every 12 hours for approximately 20 minutes per drift. Beginning August 12, drifts were increased to approximately 30 minutes to increase the counts of fish. Only migrating "bright" sockeye and coho salmon were counted.

Snorkeling has been used successfully as a method to determine fish abundance and species composition, primarily for freshwater species (Northcote and Wilkie 1963, Zubik and Fraley 1988, Slaney and Martin 1987). Snorkeling has been used as a method to count juvenile salmon with varying success (Rodgers et. al 1992, Hankin and Reeves 1988). In Washington, adult spring run chinook salmon *O. tshawytscha* have been enumerated by underwater observation (Bill Tweit, Washington State Department of Fish and Wildlife, Olympia, personal communication). Snorkel counts of adult salmon have been conducted mostly for exploratory purposes, and researchers were confident species identification was generally accurate. However, the success of snorkeling as a method to distinguish between species of adult salmon has not been well documented for large rivers.

We assumed that species identification from underwater observations was accurate. We also assumed that fish counted underwater were migrating and would not be counted during succeeding drifts. Fish observed milling in eddies and pools were generally not included in the underwater counts. Finally, we assumed that behaviors such as flight response did not differ between species, and did not impose bias.

We apportioned counts of mixed "bright" salmon to salmon species following methods developed for the Nushagak River sonar project (Miller et al. 1994a, 1994b; Brannian et al. *in press*). We pooled daily fish counts from snorkeling drifts to create time strata of at least 100 fish to estimate percent coho salmon. Exceptions were allowed when otherwise time strata would be so long they failed to reflect season changes in species composition.

We estimated the number of salmon to pass the observation tower on river bank  $i$  during time strata  $j$  and that could be identified as coho salmon ( $\hat{C}_{ij}$ ) as:

$$\hat{C}_{ij} = N_{ij} \bar{c}_{ij} \quad (1)$$

where  $N_{ij}$  is the total number of 10-minute time periods in time strata  $j$ ,  $n_{ij}$  of which were sampled and  $\bar{c}_{ij}$  is the average across those  $k=1,2,3,\dots,n_{ij}$ , 10-minute counts of coho salmon ( $c_{ijk}$ ).

The estimated variance ( $\hat{V}$ ) for our estimate of observed coho salmon ( $\hat{C}_{ij}$ ) became:

$$\hat{V}(\hat{C}_{ij}) = N_{ij}^2 \hat{V}(\bar{c}_{ij}) \left( \frac{N_{ij} - n_{ij}}{N_{ij}} \right) \quad (2)$$

which included the finite population correction factor,  $(N_{ij} - n_{ij})/N_{ij}$ , and the variance of the mean,  $\bar{c}_{ij}$ , from a systematic sample recommended by Wolter (1984):

$$\hat{V}(\bar{c}_{ij}) = \sum_{k=2}^{n_{ij}} \frac{(c_{ijk} - c_{ij,k-1})^2}{2(n_{ij} - 1)n_{ij}} \quad (3)$$

We estimated the number of salmon to pass each bank during each time strata that would have been identified as mixed "bright" salmon, sockeye or coho salmon, ( $\hat{M}_{ij}$ ) at the observation tower as:

$$\hat{M}_{ij} = N_{ij} \overline{m}_{ij} \quad (4)$$

where  $\overline{m}_{ij}$  is the average across  $n_{ij}$  10-minute counts of mixed salmon ( $m_{ijk}$ ). We estimated the number that were coho salmon ( $\hat{E}_{ij}$ ) as:

$$\hat{E}_{ij} = \hat{M}_{ij} p_{ij} \quad (5)$$

where  $p_{ij}$  is the proportion of the mixed "bright" salmon observed underwater while snorkeling along bank  $i$ , time strata  $j$  that were coho salmon.

The estimated variance ( $\hat{V}$ ) of  $\hat{E}$  became the variance of a product of two independent variables:

$$\hat{V}(\hat{E}_{ij}) = \hat{M}_{ij}^2 \hat{V}(p_{ij}) + p_{ij}^2 \hat{V}(\hat{M}_{ij}) - \hat{V}(p_{ij}) \hat{V}(\hat{M}_{ij}) \quad (6)$$

The variance of  $\hat{M}_{ij}$ ,  $\hat{V}(\hat{M}_{ij})$ , was estimated by equation 2 and 3 substituting  $M$  for  $C$  and  $\overline{m}$  for  $\overline{c}$ . The variance of the proportion ( $p_{ij}$ ) of  $r_{ij}$  mixed "bright" salmon observed underwater was estimated as:

$$\hat{V}(p_{ij}) = \frac{p_{ij}(1-p_{ij})}{(r_{ij}-1)} F_{ij} \quad (7)$$

A finite population correction factor ( $F_{ij}$ ) after Bernard (1983) was applied as :

$$F_{ij} = \frac{\hat{M}_{ij} - r_{ij}}{\hat{M}_{ij} - 1} \quad (8)$$

Our final estimate of coho salmon became the sum of the observed coho salmon ( $\hat{C}$ ) and the portion of the mixed salmon estimated to be coho salmon ( $\hat{E}$ ) summed across bank and time strata. Variances were also summed for a season total.

We were also interested in the fish counted prior to the development of good identification criteria for tower counting and collection of underwater (snorkeling) observations (August 1-8). We assumed that the pooled species composition of August 9 and 10 could be applied to the earlier time period. Bank specific estimates of percent coho salmon for August 9 and 10 pooled were calculated by adding observed and estimated coho salmon counts ( $\hat{C} + \hat{E}$ ) and dividing by total coho ( $C$ ), sockeye ( $S$ ), and mixed coho-sockeye salmon ( $M$ ) counts. The number of sockeye salmon ( $S$ ) were estimated using equations 1 and 2, substituting in the 10-minute counts ( $s_{ij}$ ) of sockeye salmon.

## *Aerial Surveys*

Aerial surveys were conducted on selected rivers in the Wood River system to estimate coho salmon abundance. Systems were selected where the presence of coho salmon was documented by previous sport and subsistence harvests or where coho salmon were observed during sockeye surveys. Spawning coho salmon were counted in the Muklung River and Silver Salmon Creek, two major tributaries to the Wood River below the counting tower (Figure 2). Ice, Youth and Sunshine Creeks draining into Lake Aleknagik above the counting towers were also surveyed. Methods followed those employed in annual salmon spawning ground surveys in Bristol Bay (Weiland et al. 1994)

Ideally, surveys are timed to coincide with the peak of spawning. Peak of spawning has not been defined for coho salmon in the Wood River system, and was assumed to occur during the period September 1-10, based on differences in peak commercial catch rates in the Nushagak and Togiak Districts, and an estimated period of peak spawning activity for Togiak District coho salmon stocks of October 1-10.

## **RESULTS**

### *Tower Counts*

A total 45,162 Pacific salmon were estimated to pass our counting site on the Wood River between August 1 and 24, 1994 (Table 1). We suspect our criteria used to determine fish species for counts made prior to August 9 and have reported them as either pink or non-pink salmon. After August 8, observers could still not determine whether some salmon were sockeye or coho salmon due to their lack of spawning colors. This category of mixed "bright" salmon represented 41.1% of the non-pink salmon counts and 15.4% of the total escapement. We feel observers correctly identified 8,382 salmon as either sockeye, coho, or mixed "bright" salmon.

A total underwater (snorkel) count of 216 mixed species "bright" salmon were made during 31 drifts along the left<sup>1</sup> bank from August 9-24 (Table 2). Data were pooled into two time strata for species composition estimates (August 9-12 and 13-24) with sample sizes of 125 and 91 salmon. A total underwater count of 457 were made during 35 drifts along the right bank from August 7-24 (Table 3). Data were pooled into three time strata for species composition estimates (August 7-12, 13-22(8:20), and 22(20:18)-24) with sample sizes of 108, 100, and 249 salmon. A new strata was begun after the 20:18 drift on August 22 when milling salmon were observed. Milling salmon were observed during subsequent drifts through August 24; consequently we pooled data for the time period when milling fish were present. Coho salmon comprised 69.6%

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<sup>1</sup> Bank to the left when looking downriver.

and 89.0% of the mixed "bright" salmon observed for the two periods on the left bank, and 55.6%, 83.0% and 100.0% of the total on the right bank.

Using percent coho salmon from underwater observations for each time strata we apportioned the mixed "bright" salmon counts to either sockeye or coho salmon. We estimate 3,084 coho salmon and 5,298 sockeye salmon past the towers from August 9 through 24. We estimate the standard deviation for coho salmon abundance at 179 with a coefficient of variation of 5.8% (Table 4).

From August 1 through 8, an estimated 16,518 coho and sockeye salmon passed our counting site. Counts were made without good species identification criteria and are reported as "non-pink" salmon (Table 1). Applying the species composition of pooled counts for August 9 and 10 results in an estimate of 6,138 sockeye and 10,380 coho salmon. For the duration of the project, August 1-24, we estimate 13,464 coho, 11,436 sockeye and 20,262 pink salmon to have entered the Wood River.

We also calculated percent coho salmon using tower count data prior to August 8, a period for which we were not confident that accurate criteria were used to determine salmon species from the towers (Table 5). The cumulative percent for the left bank was 60.5% for August 1-8 versus 64.8% for August 9-10 and 42.6% versus 62.3% for the right bank. The difference between time periods on the right bank is troublesome. It can be argued that the data by species for early August was suspect and therefore it is not a valid comparison whether in support or in contradiction of what we estimate for August 9 and 10. If the difference is real our resulting estimate will be high as the percent coho salmon increased with time.

### *Aerial Surveys*

We chose not to conduct aerial surveys of the selected rivers until September 19 due to heavy rainfall and high water levels during August. Muklung River and Silver Salmon Creek were surveyed under poor conditions, and we felt that water conditions precluded an accurate estimate. Only 20 coho salmon were observed in the Muklung River, and no count was possible in Silver Salmon Creek. However, approximately 300 coho salmon were observed at the mouth of Silver Salmon Creek in Wood River.

Another attempt was made on September 29, with improved results. Visibility in the rivers and creeks surveyed was fair. Survey counts of coho salmon included: Muklung River 48, Silver Salmon Creek 40, Ice Creek 31, Youth Creek 2, and Sunshine Creek 10. Virtually all coho salmon were observed in pairs and appeared to be close to spawning.

## DISCUSSION

For August 1-24, Miller (1995) estimated five times the number of coho salmon to have passed the Nushagak River sonar site (67,659) than as estimated past the Wood River tower site (13,464). Though both projects ended at nearly the same time (August 24 or 25), Miller (1995) estimated an additional 14,360 coho salmon or 18% of the run to have passed prior to August. In 1994, because the Nushagak River coho run was forecast less than the escapement goal, no directed commercial exploitation was allowed. Therefore most coho salmon passed through Nushagak Bay to spawn and the commercial fishery harvest totaled only 6,814 coho salmon (preliminary).

Pink salmon return to Nushagak Bay in greater abundance on even years. During August 1994 pink salmon represented 45% of the Wood River and 59% the Nushagak River counts. During the period of best species identification (August 9-24) pink salmon represented 63% and coho salmon only 14% of the Wood River counts compared to 25% pink salmon and 75% coho salmon for the Nushagak River.

We did not expect the difficulty in differentiating sockeye and coho salmon from the Wood River counting towers nor the need to collect species composition samples. Methods for sampling the escapement for species composition had to be developed in season. Water clarity ruled out capturing salmon with gillnets, and fish holding in locations suitable for capture with beach seines precluded sampling with that gear. Our assumptions connected to snorkeling as a method to determine species composition were generally thought to be correct, but were not tested. Fish were observed milling in several locations in the portion of the river counted, but we did not determine how long fish remained in those areas. Fish counted in these areas comprised a small proportion of the underwater counts, and milling behavior was not thought to greatly influence snorkel counts. No difference in behavior was observed between species.

We adopted the sample design and analysis used on the Nushagak project. Though numbers of fish observed seem low, the resulting length of the time strata for the Wood River project were no longer than those of the Nushagak River sonar project. Drift gillnet data from the Nushagak project was broken into two time strata for the left bank inshore range (August 3-10 and 11-25) and three for the right bank inshore range (August 6-8, 9-11, and 12-25).

Extensive rains and extremely high and turbid waters occurred during the peak of coho salmon spawning activity in both the Wood River and Togiak District riversheds in 1994. Though some surveys were successfully completed late on the Wood River, the numbers of fish documented were unreasonably low, considering reports from sport and subsistence fishermen, and the numbers previously observed schooled at the mouth of Silver Salmon Creek. Although no carcasses were observed on the September 29 survey, we feel that the peak of spawning had passed based on the low numbers of fish documented and considering periods of peak spawning time evidenced for coho salmon in the Togiak River watershed. The absence of carcasses could easily be explained by the heavy rains and high water velocities during late August and early September.

It remains important to define coho salmon abundance and spawning distribution throughout the Nushagak Bay watershed and we support continuation of this project for an additional year to place the Wood River run of coho salmon in perspective with the Nushagak River run. Advantages to continuing an additional year would be the absence of pink salmon in 1995, and time to prepare and improve species composition estimation. Should this project be repeated, assumptions made in snorkeling methods should be tested. Error associated with identifying species should be defined, and behavior and migration characteristics should be described.

In summary, we are most confident about the 3,084 coho salmon estimated past the Wood River tower site after August 9 and the August total pink salmon estimate (20,262). There is a concern that the 10,380 coho salmon estimate made prior to August 9 may be high. This would result if the proportion of coho salmon increased from August 1-8. Results from 1994 suggest that the coho salmon return to the Wood River system is small in comparison to the Nushagak River.

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Table 1. Daily estimates of Pacific salmon past the counting tower on Wood River, Bristol Bay, Alaska, .  
August 1 through 24, 1994.

Date	Daily Expanded Salmon Counts						Estimated Mixed Salmon		Total	
	Sockeye	Coho	Mixed	Non-Pink Total	Pinks	Total	Sockeye	Coho	Sockeye	Coho
08/01/94				1,128	300	1,428	409	719	409	719
08/02/94				3,444	786	4,230	1,289	2,155	1,289	2,155
08/03/94				2,814	816	3,630	1,041	1,773	1,041	1,773
08/04/94				2,316	924	3,240	870	1,446	870	1,446
08/05/94				2,118	696	2,814	802	1,316	802	1,316
08/06/94				1,692	1014	2,706	617	1,075	617	1,075
08/07/94				2,130	1158	3,288	786	1,344	786	1,344
08/08/94				876	570	1,446	325	551	325	551
08/09/94	258	18	732	1,008	492	1,500	257	475	515	493
08/10/94	(300)	18	510	228	612	840	166	344	(134)	362
08/11/94	(822)	36	402	(384)	288	(96)	147	255	(675)	291
08/12/94	30	12	282	324	888	1,212	119	163	149	175
08/13/94	900	54	300	1,254	936	2,190	47	253	947	307
08/14/94	192	66	138	396	1188	1,584	23	115	215	181
08/15/94	426	24	192	642	1662	2,304	27	165	453	189
08/16/94	654	66	96	816	810	1,626	14	82	668	148
08/17/94	486	48	60	594	1128	1,722	9	51	495	99
08/18/94	540	48	78	666	1146	1,812	11	67	551	115
08/19/94	264	54	138	456	852	1,308	22	116	286	170
08/20/94	564	12	114	690	1200	1,890	17	97	581	109
08/21/94	444	36	54	534	726	1,260	7	47	451	83
08/22/94	246	0	102	348	342	690	17	85	263	85
08/23/94	276	24	108	408	792	1,200	3	105	279	129
08/24/94	252	12	138	402	936	1,338	1	137	253	149
Subtotals:										
August 1-8				16,518	6,264	22,782	6,138	10,380	6,138	10,380
August 9-24	4,410	528	3,444	8,382	13,998	22,380	888	2,556	5,298	3,084
Total				24,900	20,262	45,162	7,026	12,936	11,436	13,464

Table 2. Date and time of snorkeling drifts and resulting counts of sockeye and coho salmon which would be identified as "bright" mixed salmon from the left bank counting tower, Wood River, Bristol Bay, Alaska, 1994.

Date	Time		Drift Counts of Salmon			Cumulative Counts by Strata			Percent Coho Salmon	
	Start	Stop	Sockeye	Coho	Total	Sockeye	Coho	Total	Daily	Cumulative
08/09/94	12:00		4	9	13	4	9	13	69.2	69.2
08/09/94	20:50	21:10	4	9	13	8	18	26	69.2	69.2
08/10/94	08:45	09:15	3	5	8	11	23	34	62.5	67.6
08/10/94	20:35	21:00	0	11	11	11	34	45	100.0	75.6
08/11/94	08:00	08:15	3	18	21	14	52	66	85.7	78.8
08/11/94	20:00	20:15	13	14	27	27	66	93	51.9	71.0
08/12/94	08:20	08:45	4	11	15	31	77	108	73.3	71.3
<b>08/12/94</b>	<b>19:40</b>	20:15	7	10	17	<b>38</b>	<b>87</b>	<b>125</b> <sup>a</sup>	58.8	<b>69.6</b>
08/13/94	08:40	09:25	5	12	17	5	12	17	70.6	70.6
08/13/94	20:15	21:08	0	21	21	5	33	38	100.0	86.8
08/14/94	08:35	09:17	0	2	2	5	35	40	100.0	87.5
08/14/94	20:20	20:58	1	6	7	6	41	47	85.7	87.2
08/15/94	08:30	09:17	0	3	3	6	44	50	100.0	88.0
08/15/94	20:30	21:05	1	4	5	7	48	55	80.0	87.3
08/16/94	08:40	09:12	2	6	8	9	54	63	75.0	85.7
08/16/94	19:55	20:03	0	4	4	9	58	67	100.0	86.6
08/17/94	08:25	09:12	0	3	3	9	61	70	100.0	87.1
08/17/94	19:55	20:33	0	5	5	9	66	75	100.0	88.0
08/18/94	08:00	08:38	0	2	2	9	68	77	100.0	88.3
08/18/94	19:55	20:33	1	4	5	10	72	82	80.0	87.8
08/19/94	08:05	08:41	0	1	1	10	73	83	100.0	88.0
08/19/94	20:06	20:41	0	4	4	10	77	87	100.0	88.5
08/20/94	08:03	08:42	0	0	0	10	77	87		88.5
08/20/94	19:00	19:40	0	1	1	10	78	88	100.0	88.6
08/21/94	08:00	08:28	0	1	1	10	79	89	100.0	88.8
08/21/94	20:00	20:40	0	0	0	10	79	89		88.8
08/22/94	08:03	08:47	0	0	0	10	79	89		88.8
08/22/94	20:01	20:36	0	0	0	10	79	89		88.8
08/23/94	08:07	08:47	0	2	2	10	81	91	100.0	89.0
08/23/94	20:00	20:48	0	0	0	10	81	91		89.0
08/24/94	08:08	08:42	0	0	0	10	81	91		89.0
<b>08/24/94</b>	<b>19:05</b>	19:42	0	0	0	<b>10</b>	<b>81</b>	<b>91</b>		<b>89.0</b>

<sup>a</sup> Bold entries mark the end of a time stata and estimates used to apportion mixed "bright" salmon counts to coho or sockeye salmon.

Table 3. Date and time of snorkeling drifts and resulting counts of sockeye and coho salmon which would be identified as "bright" mixed salmon from the right bank counting tower, Wood River, Bristol Bay, Alaska, 1994.

Date	Time		Drift Counts of Salmon			Cumulative Counts by Strata			Percent Coho Salmon	
	Start	Stop	Sockeye	Coho	Total	Sockeye	Coho	Total	Daily	Cumulative
08/07/94	20:00		18	23	41	18	23	41	56.1	56.1
08/08/94	13:30		8	11	19	26	34	60	57.9	56.7
08/09/94	12:00		5	0	5	31	34	65	0.0	52.3
08/09/94	20:30	20:45	5	0	5	36	34	70	0.0	48.6
08/10/94	08:00	08:25	2	3	5	38	37	75	60.0	49.3
08/10/94	20:05	20:25	1	0	1	39	37	76	0.0	48.7
08/11/94	08:35	09:05	0	0	0	39	37	76		48.7
08/11/94	20:20	20:40	1	3	4	40	40	80	75.0	50.0
08/12/94	08:00	08:15	2	3	5	42	43	85	60.0	50.6
08/12/94	12:40	13:02	1	0	1	43	43	86	0.0	50.0
<b>08/12/94</b>	<b>20:20</b>	<b>21:05</b>	<b>5</b>	<b>17</b>	<b>22</b>	<b>48</b>	<b>60</b>	<b>108</b> <sup>a</sup>	<b>77.3</b>	<b>55.6</b>
08/13/94	08:00	08:30	6	17	23	6	17	23	73.9	73.9
08/13/94	19:40	20:07	2	1	3	8	18	26	33.3	69.2
08/14/94	08:00	08:30	2	3	5	10	21	31	60.0	67.7
08/14/94	19:35	20:15	2	10	12	12	31	43	83.3	72.1
08/15/94	08:00	08:24	2	10	12	14	41	55	83.3	74.5
08/15/94	19:45	20:15	1	3	4	15	44	59	75.0	74.6
08/16/94	08:00	08:25	0	4	4	15	48	63	100.0	76.2
08/16/94	20:20	21:05	1	4	5	16	52	68	80.0	76.5
08/17/94	07:55	08:17	0	5	5	16	57	73	100.0	78.1
08/17/94	20:12	20:38	0	2	2	16	59	75	100.0	78.7
08/18/94	08:19	08:43	0	0	0	16	59	75		78.7
08/18/94	20:05	20:29	0	3	3	16	62	78	100.0	79.5
08/19/94	08:11	08:37	1	5	6	17	67	84	83.3	79.8
08/19/94	20:18	20:46	0	4	4	17	71	88	100.0	80.7
08/20/94	08:17	08:44	0	6	6	17	77	94	100.0	81.9
08/20/94	19:18	19:37	0	2	2	17	79	96	100.0	82.3
08/21/94	20:16	20:35	0	2	2	17	81	98	100.0	82.7
<b>08/22/94</b>	<b>08:20</b>	<b>08:42</b>	<b>0</b>	<b>2</b>	<b>2</b>	<b>17</b>	<b>83</b>	<b>100</b>	<b>100.0</b>	<b>83.0</b>
08/22/94	20:18	20:42	0	14	14	0	14	14	100.0	100.0
08/23/94	08:21	08:50	0	40	40	0	54	54	100.0	100.0
08/23/94	20:20	20:45	0	129	129	0	183	183	100.0	100.0
08/24/94	08:52	09:20	0	52	52	0	235	235	100.0	100.0
<b>08/24/94</b>	<b>20:05</b>	<b>20:43</b>	<b>0</b>	<b>14</b>	<b>14</b>	<b>0</b>	<b>249</b>	<b>249</b>	<b>100.0</b>	<b>100.0</b>

<sup>a</sup> Bold entries mark the end of a time strata and estimates used to apportion mixed "bright" salmon counts to coho or sockeye salmon.

Table 4. Wood River coho salmon escapement estimates and variance for August 9 through 24, 1994.

Time Strata <sup>a</sup>	Left Bank		Right Bank		Total		SD	CV
	Coho	Variance	Coho	Variance	Coho	Variance		
1	847	8,888	473	4,735	1,320	13,623	117	8.8%
2	472	8,821	1,040	7,610	1,512	16,432	128	8.5%
3			252	1,900	252	1,900	44	17.3%
Total	1,319	17,709	1,765	14,245	3,084	31,954	179	5.8%

<sup>a</sup> Time strata for species composition estimates were August 8-12 (1), and August 13-24 (2) for the left bank and August 7-12(1), August 13-22 (2), and August 23-24 (3) for the right bank. Tower counts were from August 9-24, 1994.

Table 5. Daily sum of ten-minute salmon counts, allocation of mixed salmon counts, and the percent coho salmon from the Wood River tower project, 1994.

Date	Left Bank				Right Bank			
	Ten-Minute Count of Salmon				Ten-Minute Count of Salmon			
	Sockeye	Coho	Mixed <sup>a</sup>	Pink	Sockeye	Coho	Mixed	Pink
	Allocation of Mixed Salmon Counts				Allocation of Mixed Salmon Counts			
	Sockeye	Coho	Percent Coho		Sockeye	Coho	Percent Coho	
8/01	46	61		39			57.0 <sup>b</sup>	11
8/02	34	35		23			54.5	108
8/03	21	86	30	45			64.3	91
8/04	-5	10	22	3			66.7	151
8/05	-27	3	9	1			73.9	115
8/06	52	15	78	55			63.4	114
8/07	24	21	73	39			61.4	154
8/08	7	2	29	30			60.5	65
8/09	29	1	81	68	24.6	56.4	51.7 <sup>c</sup>	14
8/10	-16	2	72	67	21.9	50.1	<b>64.8 <sup>d</sup></b>	35
8/11	-99	1	37	12	11.2	25.8		36
8/12	-1	0	7	23	2.1	4.9		125
8/13	9	1	12	25	1.3	10.7		131
8/14	4	4	2	58	0.2	1.8		140
8/15	28	3	15	108	1.6	13.4		169
8/16	22	4	6	41	0.7	5.3		94
8/17	29	3	4	66	0.4	3.6		122
8/18	21	3	5	38	0.5	4.5		153
8/19	6	1	5	7	0.5	4.5		135
8/20	12	-1	6	79	0.7	5.3		121
8/21	17	3	5	58	0.5	4.5		63
8/22	3	-1	1	2	0.1	0.9		55
8/23	8	0	4	37	0.4	3.6		95
8/24	7	0	1	25	0.1	0.9		131

Mixed category includes sockeye and coho salmon in "bright", non-spawning coloration.

The proportion of "non-pink" salmon that were coho salmon for the period (August 1-8) lacking good criteria for differentiating sockeye from coho salmon.

<sup>c</sup> The proportion of "non-pink" that were coho or estimated coho (from allocation of mixed counts) salmon for the period (August 9-10) with good criteria for differentiating salmon.

Bold entries represent estimates used to apportion "non-pink" salmon counts to coho or sockeye salmon for August 1-8.

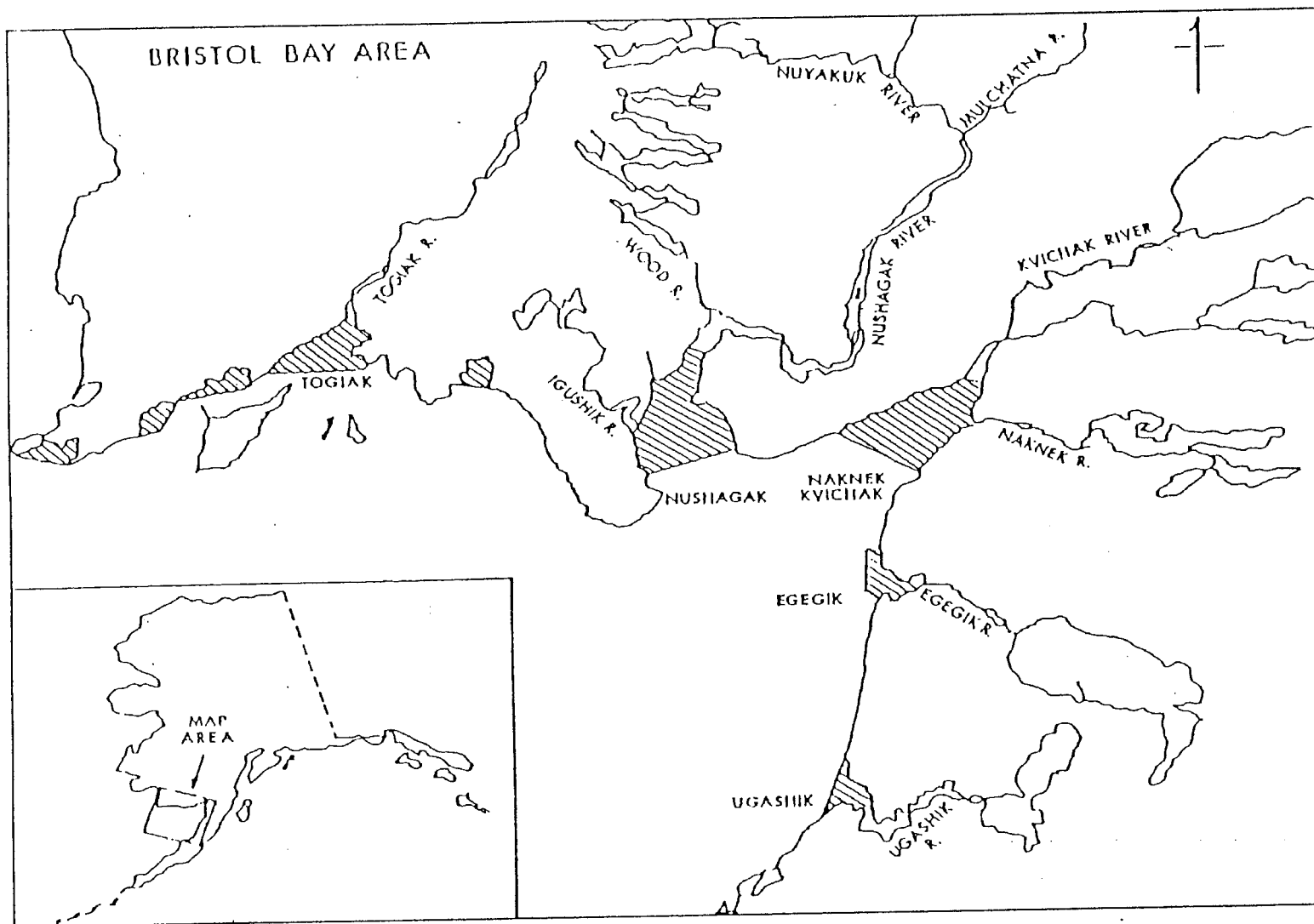


Figure 1. Bristol Bay area commercial fisheries salmon management districts.

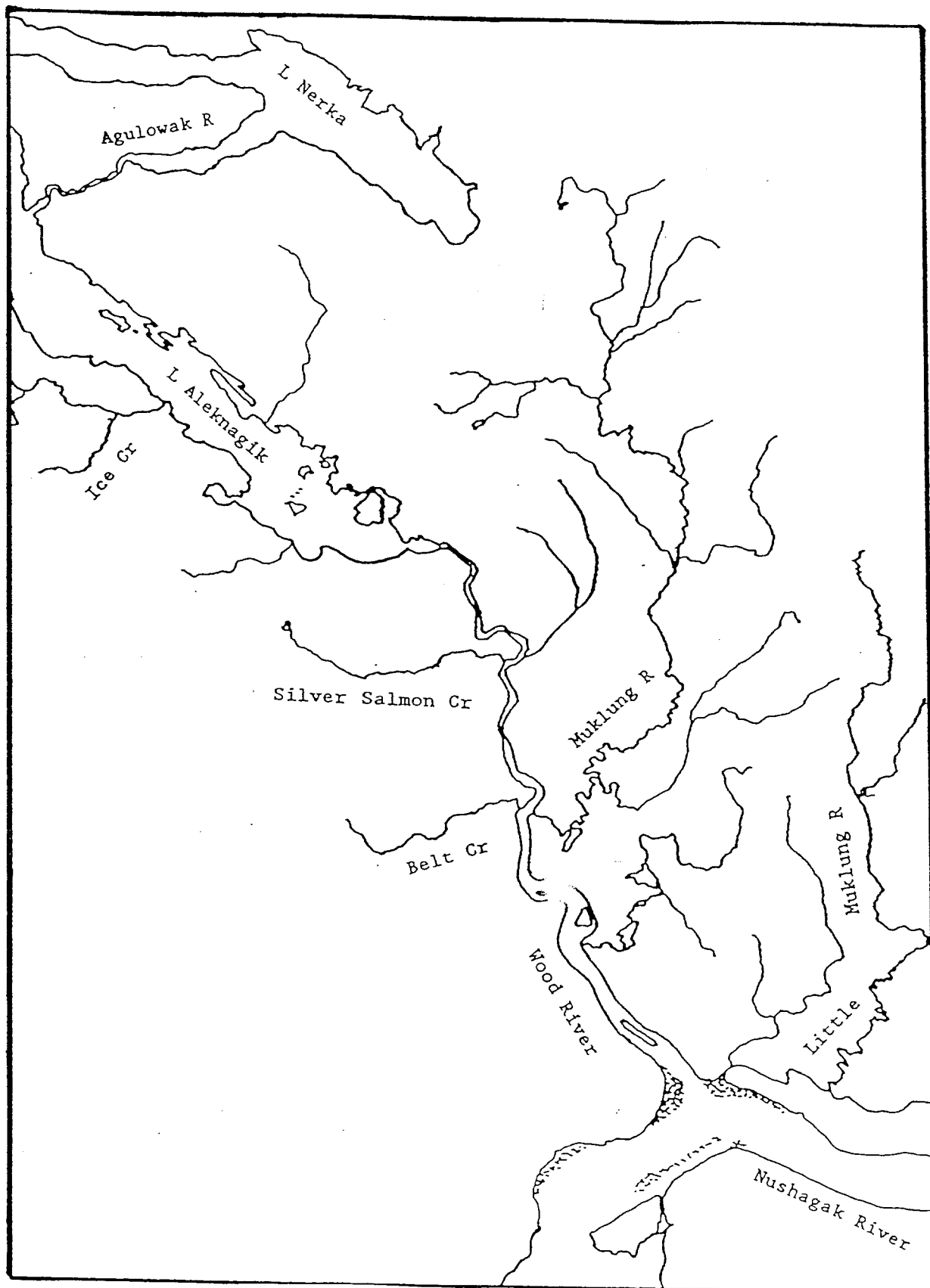


Figure 2. Wood River lake system and tributaries surveyed by air for coho salmon escapement.

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